When subjected to scene cuts and viewed in real time, the system introduced "blockiness" that was particularly visible following a cut from a complex image to a still. Examination of freeze frames showed that it took about 6 frames (1/10 second) for the "blockiness" to subside. The artifacts were most visible following a cut to a still, but also were visible following a cut to a motion sequence.

Artifacts appeared when material was subjected to two encode/decode passes through the system. During the first pass, the system introduced high levels of noise. During the second pass, the noise was increased, sharpness was reduced, and "blockiness" was introduced.

The DSC-HDTV system exhibited good chrominance dynamic range in red, green, and blue channels.

When tested for video-coder overload, DSC-HDTV exhibited no significant failures. When tested for motion-compensation overload with velocities of up to 1.0 picture height per second, the system exhibited no artifacts. No artifacts were noted in response to a sudden stop in movement.

In examining video quality for an extended service area, where only the 2-level component would be receivable, expert observers concluded that image quality for typical material would be tolerable only for short periods.

Subjective judgments of the image quality of Robust Mode DSC-HDTV also were made by non-experts. The system again performed differently across segments of test material; on average, stills were judged to be about 0.8 grade lower in quality than the reference, while motion sequences were judged to be about 1.4 grades lower in quality than the reference[6]. In general, picture quality differences between Standard and Robust Modes were more evident for stills than for motion sequences. For most stills, the difference in unimpaired video quality between Robust Mode and Standard Mode was evident to non-expert observers. Furthermore, for all materials, expert observers could distinguish easily among source, Standard Mode, and Robust Mode (expert commentary judged the Robust Mode not to produce HDTV-quality images). Expert commentary attributes the lower performance of the Robust Mode DSC-HDTV system to a significant loss in resolution. For the Robust Mode, experts also noted increased susceptibility to source noise for some pictures, increased "blockiness" following a scene cut, and increased visibility of "blockiness" in tests of video-coder overload.

[6] For the electronically generated still (S14) and motion sequence (M16), Robust Mode DSC-HDTV was judged equivalent to the reference. The average differences reported here do not include these values.

11.4.1.2 Audio Quality

There was no evidence that the audio system failed before the accompanying video.[7]

Objective tests were performed for dynamic range, total harmonic distortion (THD), 11.4.2.1 Noise Performance

When DSC-HDTV was subjected to random channel noise (based on a 6 MHz noise bandwidth), the carrier-to-noise ratio[9] (C/N) at the TOV was measured and is shown in Figure 11-1. This was also the noise threshold of the 4-level data. The system had a sharp degradation — the range between TOV and the point of unusability (POU) was 1.25 dB. The 2-level noise threshold was measured to be at a C/N of 11 dB. The Robust Mode noise thresholds, both 4-level and 2-level, were measured to be 0.5 dB lower than for the Standard Mode.

For video material used in testing, most images other than stills required significant amounts of 4-level data. In the extended service area where just the 2-level component would be receivable, expert observers concluded that the 2-level data would have utility only for short, temporary, and infrequent signal fading.

11.4.2.2 Static Multipath

The system performed well at levels that would be highly objectionable in NTSC. The TOV for echoes of +0.08 μsec, +0.32 μsec and +2.56 μsec occurred at D/U ratios of 3.3 dB (i.e., echo amplitude of 68%), 4.6 dB (59%), and 5.5 dB (53%), respectively. For an echo of -0.08 μsec, no impairment was observed up to the D/U limit of 0 dB.

11.4.2.3 Flutter

The TOV for airplane flutter of 2 Hz and 5 Hz were at D/U levels of 12.6 dB (23%) and 17.0 dB (14%) respectively.

11.4.2.4 Impulse Noise

Impulse noise performance was judged to be better than NTSC by approximately 27 dB for TOV. The range between TOV and POU was about 6 dB.

In the gated noise test at a fixed 10 Hz repetition rate, TOV was reached when the pulse width was increased to 21 μsec. Pulse width at POU was greater by approximately a factor of 10. When the pulse width was decreased to 18 μsec, TOV was reached when the pulse repetition rate was increased to 280 Hz.

[9] Caution must be exercised in comparing C/N between analog and digital systems, as definition of carrier levels is not consistent. Measurement of power level is consistent, however, among digital systems. (See section 8.3.6.)

11.4.2.5 Discrete Frequency Interference

The D/U ratio at the TOV for discrete frequency interference was -45 (±3) dB in the first adjacent channels, and between -7.3 dB and +14.0 dB in-band.

11.4.2.6 Cable Transmission

The subjective tests showed that cable transmission *per se* had no adverse effect on DSC-HDTV performance.

Among the cable-specific tests conducted the system performed better than NTSC when subjected to hum (TOV @ 11%); composite triple beat, or CTB, (TOV @ -11 dBc); composite second order, or CSO, (TOV @ -20 dBc); and local oscillator instability (> +100 kHz, < -100 kHz). Its performance was poorer than NTSC when subjected to phase noise (TOV @ -82 dBc) and residual FM (TOV @ ±1.2 kHz).

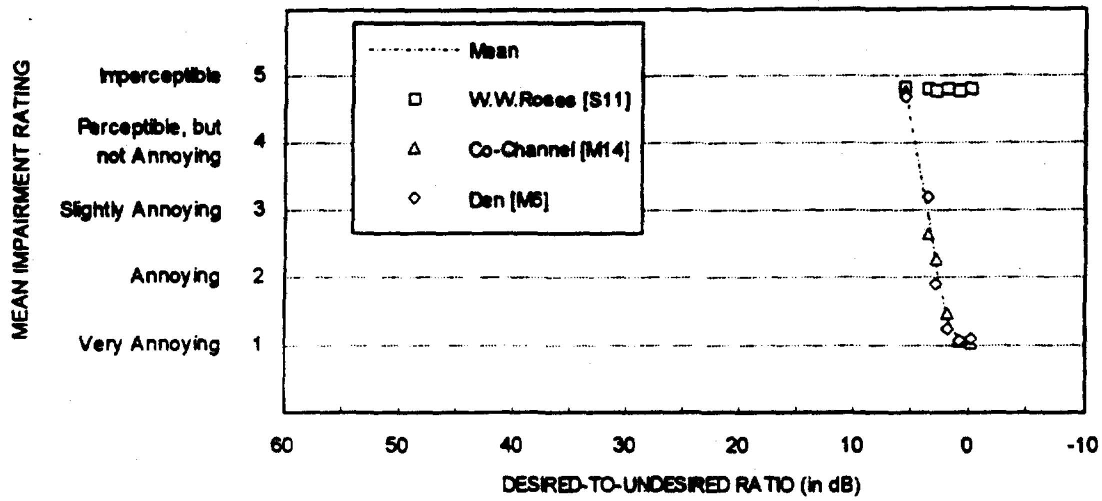

Figure 11-10. The performance of DSC-HDTV when subjected to NTSC co-channel interference for weak signal condition (-68 dBm).

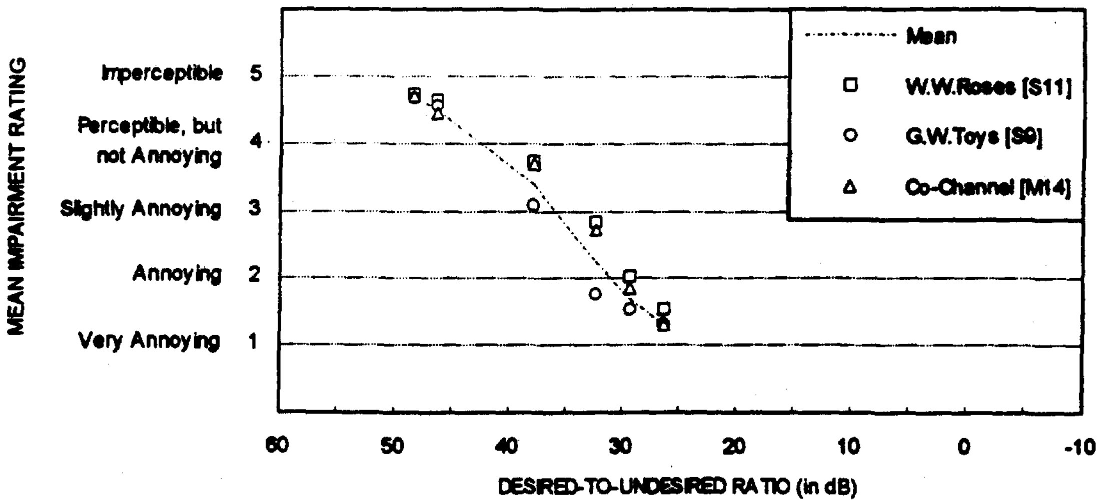

Figure 11-11. Impairment to NTSC when subjected to DSC-HDTV co-channel interference for weak signal condition (-55 dBm).

11.4.2.9 Adjacent-Channel Interference

The D/U ratio at the TOV for adjacent-channel interference into ATV is given in Figure 11-1. The D/U ratio for a mean impairment rating of 3 for adjacent-channel that DSC-HDTV could support collocation on the basis of taboo channel interference requirements.

11.4.2.11 Channel Acquisition

Under a variety of heavy impairment conditions, the DSC-HDTV system fully acquired the signal and displayed a recognizable picture within 3 seconds. Under a variety of moderate impairment conditions, a recognizable picture was displayed within 1 second.

11.4.2.12 Failure and Recovery Appearance

In general, all transmission impairments had similar manifestations in the observed video. When transmission path impairments or interfering signals were strong enough to be visible in the desired picture, they caused large "shimmering" areas of noisy video, visible blocks of various sizes, and patches of erroneous data. In most instances, the intensity and hue of the damaged portions of the image were similar to the correct video around them; only very rarely were there blocks of strongly contrasting color or luminance. Depending on the level of the impairment and complexity of the desired image, the effects of the impairment persisted for about 2-5 seconds after the impairment was removed. Higher levels of impairment created more frequent and larger affected regions. Complex images were more prone to visible effects of a given impairment level than were simpler images.

During a loss of signal, or when the signal was overwhelmed with impairments, the image "dissolved" into blocky artifacts or barely recognizable video and then froze. Upon reacquisition, the blocks "dissolved" into a good image in a period of 2-5 seconds.

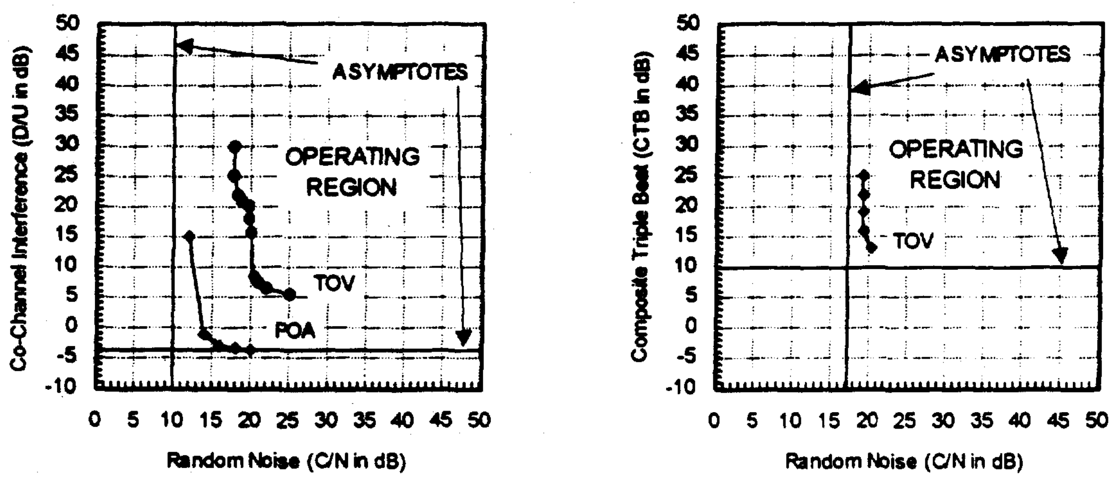

Figure 11-13. Multiple impairments into DSC-HDTV. (Left) POA and TOV for NTSC co-channel interference versus random noise. (Right) TOV for composite triple beat versus random noise.

11.4.3 Scope of Services and Features

11.4.3.1 Data

Two separate channels were provided for ancillary data in the system tested. The total capacity of 413 kbits/sec was divided into one channel of 30 kbits/sec sent as 2-level data and another of 383 kbits/sec sent as 4-level data.

11.4.3.2 Encryption

The system tested did not have encryption implemented. The proponent expects to develop encryption with industry participation.

11.4.3.3 Addressing

The addressing information is transmitted through the ancillary data channel.

11.4.3.4 VCR Capability

The proponent claims that the current S-VHS mechanism is sufficient for the 21.5 Mbits/sec DSC-HDTV data, and that such 1/2 inch cassette equipment exists in prototype form. According to the proponent, the system knows what fraction of the original image is contained in the displaced frame difference (DFD). A usable picture is obtained without motion compensation by amplifying the DFD by a factor proportional to the inverse of the leak factor. This can be used for VCR forward or reverse scan modes when only a small portion of each compressed frame is acquired. In addition, the segment headers are needed to identify the slice numbers from the acquired data. The picture would appear "blocky" with some slices lost, but suitable for rapid searching. Still frame is simple if the VCR had been playing. If random access to a particular frame on the tape is required, the decoding of several frames leading up to it is needed to achieve full quality. Splicing is optimal if each splice starts with a scene change. Otherwise, the decoder can be signaled to initiate a leak factor inversion for fast startup at the beginning of each splice or insert. Cropping is possible by manipulation or replacement of compressed slices. Image processing for special effects is best performed in the pixel domain after decoding. Square pixels and progressive scanning simplify the implementation of special effects.

11.4.4 Extensibility

11.4.4.1 To No Visible Artifacts

The proponent suggests a rate of 41 Mbits/sec for no visible artifacts regardless of detail and motion, and claims that this can be accomplished with a small change to the compressed video interface.

11.4.4.2 To Studio Quality Data Rate

Claims are made that the compression techniques used for the broadcast of DSC-HDTV are easily simplified to produce a 200 Mbits/sec signal for use in the studio. This signal uses only intraframe processing, and thus is suitable for all editing and special effects processing. The claim is made that the quality is suitable for multiple decoding/encoding as required. This bit rate is suitable for serial data interfaces and also for video tape recording on D-1 VTRs.

11.4.4.3 To Higher Resolution

If it is desirable in the future to maintain higher pixel numbers in the production studio, the higher-resolution signal could be compressed into the 200 Mbits/sec studio signal plus a high-frequency residual signal. The standard DSC-HDTV system would code the studio signal frames, and a simple augmentation encoder would code the residual signal. The final output of editing or special effects could still be recorded using the 200 Mbits/sec portion of the compressed signal.

11.4.4.4 Provision for Future Compression Enhancement

The proponent suggests that the compression algorithm permits improvements in the selection of vector quantization patterns from the codebook, motion estimation, perceptual error threshold computation, buffer control, leak adaptation, and transmission prioritization. These improvements can be made without changing receivers or the transmitted data rate.

11.4.5 Interoperability Considerations

11.4.5.1 With Cable Television

Information on the performance of DSC-HDTV over cable can be found in Section 11.4.2.6.

11.4.5.2 With Digital Technology

Since this system is all-digital, the advantages of all-digital systems apply.

11.4.5.3 Headers/Descriptors

The tested system did not have explicit headers and descriptors. However, ancillary data space was provided for a number of purposes including headers/descriptors.

11.4.5.4 With NTSC

As the DSC-HDTV line-rate is directly related to NTSC, transcoding to NTSC is straightforward. Conversion to and from NTSC has been demonstrated using real-time hardware. Up-conversion from NTSC requires line tripling, horizontal line-rate conversion and interpolation.

11.4.5.5 With Film

The encoder buffer control automatically detects the presence of 24 fps or 30 fps scene material from film sources. When a film source is detected, an alternate buffer control algorithm will be used which takes advantage of repeated frames in the source and minimizes variations in distortion between repeated frames. If film is detected, all video segments will undergo 2-level transmission for maximum coverage area and minimum video data rate. The alternate buffer control for film mode was not completed in time for testing.

11.4.5.6 With Computers

Progressive scanning and square pixels, both of which are used in this system, are important factors for interoperability of an HDTV system with computers. The frame rate used in DSC-HDTV is 59.94 Hz.

11.4.5.7 With Satellites

The maximum total data rate for DSC-HDTV is 21.5 Mbits/sec. As satellite data communication channels use a constant bit rate, the variable bit rate used by DSC-HDTV for terrestrial transmission makes it necessary for the bit stream to be reformatted for satellite transmission. The reformatted bit stream must contain the data needed to permit reconstruction of the variable-rate bit stream for separate 2-level and 4-level terrestrial modulation. The proponent has suggested transmitting two programs per channel using TDM or SCPC in a 36-Mhz transponder, and has considered both two programs/channel and one program/channel DBS scenarios.

11.4.5.8 With Packet Networks

The DSC-HDTV symbols are organized in a form of packet structure using fixed-length data segments. Segment headers include pointers to slices (64H x 48V), so that packet loss results in loss of, at most, a few slices prior to error concealment. The segments make up data frames of duration 1/59.94 sec. In order to carry DSC-HDTV on an ATM network, the data in data frames would be encapsulated in the ATM cell structure. While the number of bits in a data frame varies because of the 2-level transmission, circuit-switched networks use constant bit rate. The proponent suggests repeating 2-level segments for added robustness to fill out the data stream for a constant-bit-rate channel. For a packet network, packets can be used as needed to carry the actual varying bit rate. When cell loss is detected, the decoder will perform error concealment by replacing missing segments with default data or with pixel data from a previous frame.

11.4.5.9 With Interactive Systems

The proponent claims that the delay through the encoder and decoder for the DSC-HDTV system is about 14 frames (224 msec). The proponent claims that an enhancement to the current system allows the latency to be determined by the encoder for interactive applications that require lower latency. Acquisition time is reported in Section 11.4.2.11.

11.4.5.10 Format Conversion

11.4.5.10.1 With 1125/60

Up-converting to the Common Image Format (1920 x 1080) requires 2:3 interpolation horizontally and vertically. SMPTE 240M uses 1035 active lines and would require 16:23 vertical interpolation. Colorimetry is the same as SMPTE 240M.

11.4.5.10.2 With 1250/50

This difficult conversion is somewhat easier with a progressive system such as DSC-HDTV than with an interlaced system.

11.4.5.10.3 With MPEG[10]

Although the DSC-HDTV decoder shares many commonalties with MPEG-1 decoders, the DSC-HDTV decoder would require modification to decode MPEG-1. MPEG-1 decoders will not decode DSC-HDTV.

11.4.5.10.4 With Still Image

The proponent suggests that conversions with JPEG, Photo CD and CD-I are possible with straightforward spatial filtering after decompression without the flicker that might be introduced by an interlaced display. In simple cases, line and sample doubling or sub-sampling may suffice.

11.4.5.11 Scalability

It is possible to process the 2-level data only and display the images corresponding to that portion of the video information. Decoding only 2-level data will result in a substantially reduced-quality image for scenes that are difficult to encode (requiring large amounts of 4-level data). In such a case, the loss of the 4-level data affects both the temporal and spatial resolution. Where temporal scaling is needed, the process is simplified by the progressive scan used in DSC-HDTV. The proponent has suggested using the motion vectors available at the decoder to perform motion-compensated frame interpolation. The proponent suggests that picture-in-picture be done by windowing on slice (64H x 48V) boundaries.

11.5 SYSTEM IMPROVEMENTS

11.5.1 Already Implemented

11.5.1.1 Vertical Noise Coring in Video Source

The purpose of this improvement was to increase overall coder efficiency and improve

11.5.1.3 Modified Quantizers, Perceptual Weights, Scale Factors, and Variable Length Codes

To reduce artifacts in saturated color regions, in complex or noisy pictures, and for iso-luminance patterns, entries in a variety of tables in the encoder and decoder have been modified. There were no hardware changes.

11.5.1.4 Improved Leak Calculation

The purpose of this improvement was to remove temporal breathing, reduce buffer oscillations, and improve overall coding efficiency. The method of fixing "limit cycles" associated with leak has been replaced.

11.5.1.5 Improved Error Concealment via Unity Leak

The purpose of this improvement was to conceal errors in still pictures and, where accurate motion vectors are available, in motion pictures. In the presence of heavy errors, unity leak is used to replace blocks with errors. Only the decoder was affected.

11.5.1.6 Modified Buffer Control, Increased Decoder Efficiency and Controlled Audio/Video Delay

To provide faster scene changes and a better distribution of 2-level and 4-level segments, parameter changes have been made in the encoder. To control the relative delay between the audio and video display, modifications have been made in the encoder and decoder.

11.5.1.7 Reduction of Pilot Level

To improve upper-adjacent ATV-into-NTSC interference and to lower transmitted signal power, the pilot level for both 2-level and 4-level data has been reduced by 3 dB.

11.5.1.8 Changes in Offset Frequency and Dispersion

To eliminate a color stripe observed in ATV-into-NTSC co-channel interference tests, the transmitter carrier frequency has been offset an additional 30 Hz.

To lower the peak-to-average power ratio by 1.5 dB, a change has been made in the dispersion.

11.5.1.9 Correction of Slice Error Problem

The purpose of this improvement was to correct a hardware problem in the decoder that caused a timing fault in the compressed video data deformatter, giving occasional undetected errors in a given slice (64H x 48V pixel block).

11.5.1.10 Filtering of Input to Motion Estimator

The purpose of this improvement was to overcome a "half-pel" flashing block problem that occurred when an accumulator overflow condition caused erroneous motion vectors to be computed for several 32H x 16V blocks in a scene.

11.5.1.11 Adaptive Two-Dimensional Source Filtering

To improve picture quality, especially for complex pictures, a slight spatial two-dimensional frequency roll-off is performed in the input to the encoder based on an estimate of picture

11.5.2.3 ATSC T3/186 Audio and Flexible Assignment of Audio, Video, Ancillary and Conditional Access/Encryption Data

To fulfill the audio requirements of T3/186, a 5.1-channel sound system will be implemented using the Dolby AC-3 system, and two additional independent audio channels will be implemented using the Dolby AC-2A system. This choice may be revisited if another audio sub-system becomes available before testing begins.

To allow flexible allocation of data, headers will be included. Flexible allocation capability will be implemented to the extent that the interfaces to the various services to be carried are adequately specified.

[This page intentionally left blank.]

12. ADVANCED DIGITAL HDTV

12.1 SYSTEM OVERVIEW

AD-HDTV, proposed by the Advanced Television Research Consortium (ATRC) is a digital simulcast system that requires a single 6 MHz television transmission channel.[1] The ATRC includes: David Sarnoff Research Center, North American Philips, Thomson Consumer Electronics, NBC, and Compression Labs, Incorporated. The AD-HDTV video source is an analog RGB signal with 1050 lines, 2:1 interlaced, a 59.94 Hz field rate, and an aspect ratio of 16:9. A matrix converts the RGB color signals to Y-Cr-Cb components, conforming to the SMPTE 240M representation and colorimetry specification. The luminance video sampling frequency is 56.64 MHz. The source and display format is interlaced with 960 lines by 1500 pixels per line. To create the internal progressive scan format used by the system's frame based coding, the interlaced source is transcoded into a 960 line by 1248 pixels per line, progressively scanned, 29.97 frames per second format. After format conversion, the two color-difference signals are decimated by a factor of two both horizontally and vertically, resulting in a sampling density one fourth that of the luminance signal. The video compression uses an adaptation of the MPEG-1 (Moving Picture Experts Group) standard.[2] The system uses two separate transmission channels, each with 32 QAM modulation, totaling 24 Mbits/sec. The high priority (HP) channel carries 4.8 Mbits/sec of data and is of higher power than the standard priority (SP) channel with 19.2 Mbits/sec of data. The purpose of the two-channel approach is to provide a measure of "graceful degradation" and to reduce co-channel interference from and into NTSC. The audio channels are compressed using a proprietary standard called MUSICAM that is related to layers 1 and 2 of the 3-layer MPEG audio standard. The audio is sampled at 48 kHz with 16 bit precision. Audio in the tested system supported two stereo pairs of 256 kbits/sec each; they were transmitted in the HP channel. An additional 256 kbits/sec was provided for data.

12.2 SPECTRUM UTILIZATION

The AD-HDTV analysis was conducted under two allotment scenarios (using both VHF and UHF channels for ATV stations, and using only UHF channels) and two sets of interference constraints (considering only co-channel interference, and both co-channel and adjacent-channel interference). In addition, the impact of taboos was assessed by re-calculating

[1] The ATRC was unable to deliver its AD-HDTV system to the test laboratories at the beginning of the scheduled test slot. The resulting delay slightly truncated testing performed on the system. In addition, an incorrectly included filter in the AD-HDTV tuner was discovered during testing. The Advisory Committee decided to rerun certain tests after the proponent replaced the incorrect filter. Subsequently, SS/WP2 agreed that the data from the retest, not from the corresponding original test, should be used by the Advisory Committee for analysis and evaluation of the proponent's system.

[2] See Section 8.3.8 for a discussion of MPEG, the MPEG-1 standard, and the MPEG-2 development effort.

coverage and interference for each case assuming the taboo performance measured in the laboratory.

Figure 12-1 shows planning factors, specific to the AD-HDTV system, as derived from test results.[3] The numbers in the figure are desired-to-undesired ratios (D/U) in dB. The values for interference into NTSC are based on CCIR Impairment Grade 3 (slightly annoying) as determined from the ATEL subjective tests.[4] Because the ATV service is intended to be an improvement over NTSC, interference into ATV is based on CCIR Impairment Grade 4 (perceptible but not annoying) if the range between TOV and POA exceeds 5 dB. Otherwise, the TOV power level is used. AD-HDTV demonstrated a "cliff effect" and thus D/U values are based on TOV data. Also, the data show that AD-HDTV can support collocation on both the upper and lower adjacent-channels.

Co-Channel	D/U (dB)
ATV-into-NTSC	+34
NTSC-into-ATV	+0.50
ATV-into-ATV	+19.1

Carrier-to-Noise	+18.4

Adjacent-Channel	D/U (dB)
Lower ATV-into-NTSC	-16.0
Upper ATV-into-NTSC	-8.9
Lower NTSC-into-ATV	-38
Upper NTSC-into-ATV	-36
Lower ATV-into-ATV	-33
Upper ATV-into-ATV	-16.8

Figure 12-1. Planning factors specific to AD-HDTV.

12.2.1 Accommodation Percentage

AD-HDTV could provide a 100% accommodation of all NTSC assignments for co-channel only, and co-channel and adjacent-channel constraints, under both the VHF/UHF and UHF scenarios. The accommodation is achieved at the expense of reducing the ATV and NTSC service areas. No attempt was made to reduce interference to NTSC service by adjusting either ATV or NTSC power.

[3] As determined by SS/WP2, spot check data are not included in Figure 12-1; however, spot check data, marginally different from the original data, were used in spectrum utilization analyses. The spot check data used by PS/WP3 were for Co-Channel NTSC-into-ATV (0.82 dB), Co-Channel ATV-into-ATV (18.4 dB), and Carrier-to-Noise (18.1 dB). Spot check data were used also for the effect of taboo interference. Use of the original data would have affected all the spectrum utilization results. For example, use of spot check data is believed to affect co-channel interference results by slightly improving ATV-into-NTSC and ATV-into-ATV, and to a lesser degree, worsening NTSC-into-ATV.

[4] For spectrum utilization analysis, a correction factor was applied to weak signal level TOV data to estimate a CCIR Impairment Grade 3 for Adjacent-Channel Upper ATV-into-NTSC because subjective assessment was not performed at weak signal level.

12.2.2 Service Area

Figure 12-2 depicts the interference-limited service area of each ATV station, during the transition period, relative to the interference-limited service area of its companion NTSC station under the VHF/UHF scenario, taking into account both co-channel and adjacent-channel constraints. In this graph, the 1,657 current NTSC stations are placed in order of decreasing ATV to NTSC service area ratio. Examination of the graph reveals that 10.3% (170) of the ATV stations under this scenario would have an ATV service area at least 20% larger than their companion NTSC service area and 95% (1,579) would have an ATV service area at least 80% of their companion NTSC service area. The total ATV interference-limited service area for all 1,657 stations is 39.2 million square kilometers.

Figure 12-3 shows the interference statistics for the VHF/UHF scenario. During the transition period, 46.5% of ATV stations would receive no interference. This would rise to 55.2% after the transition period ends. Also during the transition period 3.4% of the ATV stations would receive interference in more than 35% of their noise-limited coverage area. This would fall to 3.2% after the transition period ends. The total interference area created within the ATV noise-limited coverage area during the transition period is 2.94 million square kilometers. This would decrease to 2.45 million square kilometers after the transition period ends. Of the existing NTSC stations, 55.7% would not receive any new interference because of the ATV service, while 2.8% would receive new interference in more than 35% of their Grade B area. The total new interference into NTSC created under this plan is 1.77 million square kilometers.

When taboos are included in the interference calculations for the VHF/UHF scenario, the number of ATV stations with no interference during the transition period is 43.2%; the number of ATV stations with interference in more than 35% of their noise-limited coverage area is 3.4%. The number of NTSC stations receiving no new interference is 50.0%; the number of NTSC stations with interference in more than 35% of their Grade B area is 3.1%.

When the adjacent-channel constraints of Figure 12-1 are not included in the VHF/UHF scenario, the allotment/assignment table is different. In that case, 17.5% (290) of the ATV stations would have an ATV service area at least 20% larger than their companion NTSC service area and 99% (1,633) would have an ATV service area at least 80% of their companion NTSC service area. During the transition period, 76.0% of ATV stations would receive no interference. This would rise to 80.1% after the transition period ends. Also during the transition period, 0.9% of the ATV stations would receive interference in more than 35% of their noise-limited coverage area. This would remain at 0.9% after the transition period ends. Of the existing NTSC stations, 62.6% would not receive any new interference because of the ATV service, while 2.3% would receive new interference in more than 35% of their Grade B area.

Figure 12-4 depicts the interference-limited service area of each ATV station, during the transition period, relative to the interference-limited service area of its companion NTSC

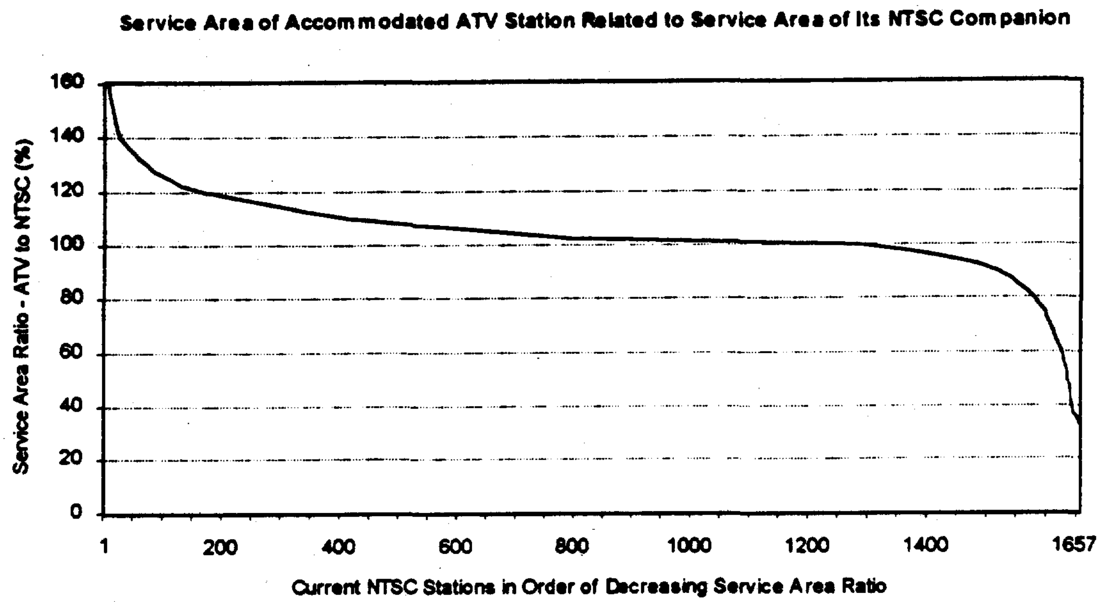

Figure 12-2. AD-HDTV VHF/UHF Scenario — Interference-limited service area of each ATV station relative to the interference-limited service area of its companion NTSC station (co-channel and adjacent-channel constraints).

Interference Area Compared to Coverage Area	ATV Stations with Interference		NTSC Stations with Added Interference Due to ATV
	During Transition	After Transition	
No Interference	46.5 %	55.2 %	55.7 %
0 - 5 %	20.5 %	18.5 %	15.9 %
5 - 10 %	13.5 %	10.0 %	9.0 %
10 - 15 %	7.6 %	6.3 %	6.5 %
15 - 20 %	3.9 %	2.8 %	4.0 %
20 - 25 %	2.3 %	1.9 %	3.0 %
25 - 30 %	1.6 %	1.4 %	1.5 %
30 - 35 %	0.7 %	0.6 %	1.6 %
> 35 %	3.4 %	3.2 %	2.8 %

Figure 12-3. AD-HDTV VHF/UHF Scenario — Interference characteristics (co-channel and adjacent-channel constraints).

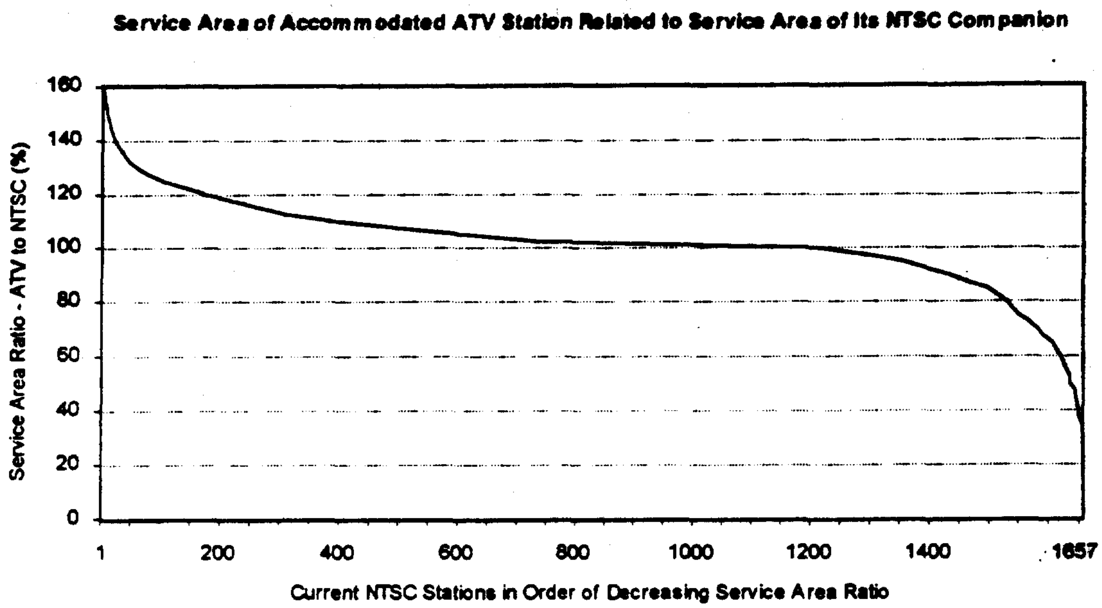

Figure 12-4. AD-HDTV UHF Scenario — Interference-limited service area of each ATV station relative to the interference-limited service area of its companion NTSC station (co-channel and adjacent-channel constraints).

Interference Area Compared to Coverage Area	ATV Stations with Interference		NTSC Stations with Added Interference Due to ATV
	During Transition	After Transition	
No Interference	46.8 %	52.7 %	59.7 %
0 - 5 %	17.0 %	16.5 %	9.4 %
5 - 10 %	10.4 %	8.9 %	6.0 %
10 - 15 %	7.6 %	5.8 %	4.1 %
15 - 20 %	5.0 %	4.5 %	2.9 %
20 - 25 %	3.4 %	2.6 %	3.0 %
25 - 30 %	2.5 %	2.1 %	2.8 %
30 - 35 %	1.9 %	1.8 %	2.4 %
> 35 %	5.3 %	5.2 %	9.7 %

Figure 12-5. AD-HDTV UHF Scenario — Interference characteristics (co-channel and adjacent-channel constraints).

Average Effective Radiated Power Level		Number of TV Stations			
		VHF/UHF Scenario			UHF Scenario
(dBk)	(kW)	Low VHF	High VHF	UHF	UHF
Less than 5	Less than 3.2	10	20	89	89
5 - 10	3.2 - 10.0	3	12	44	44
10 - 15	10.0 - 31.6	4	10	55	60

Subsystem	Cost (thousands)
Satellite Receiver, Demodulator, Decoder	$ 13.5
Character Generator, Still Store, Two 28" Monitors	200.0
Routing Switcher (10 x 10), Master Control	125.0
2 ATV VTRs and Monitors	170.0
NTSC Upconverter, including Line Doubler	19.0
ATV-to-NTSC Downconverter	15.0
34" Monitor, Seven 17" Monitors, Eight Decoders	110.0
ATV Encoder	280.0
STL Subsystem	92.5
ATV Modulator, ATV Exciter	35.0
ATV Transmission Subsystem	725.5
TOTAL COST	$1,785.5

Figure 12-7. Equipment cost for an AD-HDTV transitional station.

Subsystem	34" Widescreen Direct View Receiver	56" Widescreen CRT Type Projector
Signal Processing Components	$ 127	$ 127
Audio Amplifiers, Speakers	30	30
Scan System, Power Supply, Video Amps	63	176
Display	700	1,050
Cabinet	90	140
TOTAL MATERIAL COST	$1,006	$1,522

Figure 12-8. Material cost data for an AD-HDTV receiver.

12.4 TECHNOLOGY

12.4.1 Audio/Video Quality

In video subjective tests of AD-HDTV, the system performed consistently across segments of test material with no difference between still and moving materials. For 8 of the 9 stills and 14 motion sequences, AD-HDTV was judged, on average, to be about 0.3 grade lower in quality than the 1125-line studio reference. The remaining still, electronically generated, was judged to be better in quality than the reference.[5]

Problems were noted when the system was tested for video-coder and motion-compensation overload. No significant problems were reported when the system was subjected to scene cuts, noisy source material, and to a sudden stop in motion.

During system-specific tests, expert observers noted that the audio remained useful, but not unimpaired, over the range between the SP and HP thresholds. There was no evidence that the audio system failed before the accompanying video.

12.4.1.1 Video Quality

Subjective judgments of image quality by non-experts are summarized in Figure 12-9. Scores are the differences between judgments of the reference and judgments of AD-HDTV for 9 stills and 14 motion sequences. For 8 of the 9 stills, AD-HDTV was judged, on average, to be 0.3 grade (i.e., about 6 points on the 100-point scale) lower in quality than the 1125-line studio reference; for the remaining still (S14), the system was judged to be 0.9 grade higher in quality than the reference (this may reflect reduced visibility of interlacing artifacts in the AD-HDTV rendering of this picture). For motion sequences, AD-HDTV also was judged, on average, to be 0.3 grade (i.e., about 6 points) lower in quality than the reference.

AD-HDTV performed consistently across all segments of test material. Differences ranged